Hospitals Productivity Measurement Using Data Envelopment Analysis Technique

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Abstract

Background: This study aimed to measure the hospital productivity using data envelopment analysis (DEA) technique and Malmquist indices.

Methods: This is a cross sectional study in which the panel data were used in a 4 year period from 2007 to 2010. The research was implemented in 12 teaching and non-teaching hospitals of Ahvaz County. Data envelopment analysis technique and the Malmquist indices with an input-orientation approach, was used to analyze the data and estimation of productivity. Data were analyzed using the SPSS.18 and DEAP.2 software.

Results: Six hospitals (50%) had a value lower than 1, which represents an increase in total productivity and other hospitals were non-productive. the average of total productivity factor (TPF) was 1.024 for all hospitals, which represents a decrease in efficiency by 2.4% from 2007 to 2010. The average technical, technologic, scale and managerial efficiency change was 0.989, 1.008, 1.028, and 0.996 respectively. There was not a significant difference in mean productivity changes among teaching and non-teaching hospitals ($P>0.05$) (except in 2009 years).

Conclusion: Productivity rate of hospitals had an increasing trend generally. However, the total average of productivity was decreased in hospitals. Besides, between the several components of total productivity, variation of technological efficiency had the highest impact on reduce of total average of productivity.

Keywords: Hospital productivity, DEA, Malmquist indices, Technical efficiency

Introduction

Hospital is one of the main organizations in health service system. It has a special importance in health economics, and imposes higher costs on the health system compared to the other health system components (1, 2). Hospitals are the main consumer of resources in any health sector thus; improvement of their efficiency is the main way to decrease the hospital costs (3).

Thus, providing criteria for evaluation of hospital performance and productivity is important (2, 4). These features are doubled, especially in develop-ing countries, considering their economic structure and extreme vulnerability to deal with fluctuations in currency and commodity markets. In a way, that full response to the needs of consumers in this sector, even in the most advanced countries, seems to be out of reach (5, 6). Hence, the Iranian hospitals are no exception from this issue. In this situation, the hospitals managers' strategies for reducing the costs and increasing the productivity is necessary (7). Productivity is one of the important concepts in assessing the performance

of organization over time. Productivity expresses a kind of relationship between the amount of the produced goods or services and the amount of resources, which is consumed in producing goods and services. Therefore, productivity is a measure that shows the relationship between outputs and inputs (8). Productivity indicators show improvement or reduction in performance (9). The information obtained from productivity sub-indicators are used to identify the problems of unites, define the strategies, and in case of need, make change in the staff behaviors (10).

Several techniques to assessment hospital efficiency and productivity are usually considered either parametric or non-Parametric. (11). Non-parametric methods such as data envelopment analysis are the most popular (12).

This study was performed to determine the productivity rate of hospitals by using Data Envelopment Analysis technique in Ahvaz, Iran.

Materials and Methods

This is a cross sectional study in which the panel data were used in a 4 year period from 2007 to 2010. The research was implemented in 17 teaching and non-teaching hospitals of Ahvaz County, southern Iran. As five hospitals did not agree to participate in this study; and finally 12 hospitals were assessed. Variables were selected based on the experts' opinions and previous studies (1, 13, 14). The set of input and output variables that we have used in this study are similar to those applied in other studies (15-17). The input measures included are number of nurses, number of occupied beds and number of physicians. The output measures included are number of outpatients and inpatients, average of hospital stay, and number of major operations

Data collection

Data were collected by studying the medical records and documents of the hospitals retrospectively. Data were collected using standard checklists prepared by the Ministry of Health.

Data Analysis

Data envelopment analysis technique and the Malmquist indices with an input-orientation approach, was used to analyze the data and estimation of productivity. We selected input-orientation approach and variable returns to scale (VRS) model for data analysis. In input-orientation approach, decision-making units (DMUs) can change their inputs (18, 19). When the productivity and efficiency measurement are based on the input-orientation approach (minimizing the production factors), a value of more than one show productivity decline and a value of less than one show Productivity growth (1, 7). Data was analyzed by SPSS.18 and DEAP.2 software.

Results

We studied twelve hospitals in four-year periods. As noted in Table 1, J hospital has the highest value and H hospital has the lowest value of total productivity changes. Therefore, the range of changes of productivity for hospitals was from 0.785 to 1.127, and J and H hospitals had the best and worst performance respectively. K hospital had the maximum value of changes in technical, technological, managerial and scale efficiency. H hospital had the lowest technical and scale efficiency changes, G hospital had the lowest technological efficiency changes and I hospital had the minimum management performance changes. Six hospitals (50%) had a value lower than 1, which represents an increase in total productivity between 2007 and 2010. Five hospitals (41.66 %) had a value higher than 1, which represents a decrease in total productivity and one hospital (8.33 %) had a value equal to 1 which reflects stagnation in total productivity changes.

According to the Table 2, the average of total productivity was 1.024, which reflects a decrease in productivity changes by 2.4% in study period. The average total productivity change of all factors in the year 2008 was more than 1, which shows that the level of productivity of hospitals has been decreased in this year. Changes in technological performance had a negative impact on

the rate of productivity and had the main role in reducing productivity.

As noted in Table 3, mean of the productivity change had a significant difference among teaching and non-teaching hospitals (*P*=0.001) in 2009

and had not significant differences in other years. In general, there was no significant difference in average of productivity changes between teaching and non-teaching hospitals.

Table1: Efficiency and total productivity change by hospital type (Teaching and non-teaching hospital)

Hospital type N=12	Technical efficiency change	Technological efficiency change	Managerial efficiency change	Scale efficiency change	Productivity change	Productivity status
A(teaching)	0.873	0.985	0.889	0.982	0.860	Productive
B(teaching)	0.960	1.008	0.907	1.058	0.968	Productive
C(teaching)	0.955	0.973	1	0.955	0.929	Productive
D(teaching)	0.934	1.07	0.906	1.032	1	Neutral
E(teaching)	0.997	1.003	0.965	1.034	1.001	Non-productive
F(nonteaching)	1.077	1.007	1.042	1.033	1.085	Non-productive
G(nonteaching)	1	0.861	1	1	0.861	Productive
H(nonteaching)	0.882	0.889	1	0.882	0.785	Productive
I(nonteaching)	0.909	0.986	0.858	1.059	0.896	Productive
J(nonteaching)	1	1.127	1	1	1.127	Non-productive
K(nonteaching)	1.486	1.412	1.384	1.074	1.097	Non-productive
L(nonteaching)	1	1.105	1	1	1.105	Non-productive
Mean	0.996	1.028	0.989	1.008	1.024	Non-productive

Table 2: Efficiency and productivity change in three years-period (200-8-2010)

Productivity status	Total productivity change	Scale efficiency change	Managerial efficiency change	Technological efficiency change	Technical efficiency change	Year*
Non-productive	1.226	1.007	0.963	1.265	0.969	2008
productive	0.972	0.980	1.071	0.926	1.049	2009
productive	0.901	1.038	0.937	0.926	0.972	2010
Non-productive	1.024	1.008	0.989	1.028	0.996	Total Mean

*In this study, the 2007 year is basic year for assessment other years (so has not been showed in table)

Table 3: Comparison of productivity change between teaching hospitals and non-teaching

Year	Productivity			Total productivity change (3 year)	Productivity status
Hospital type	2008	2009	2010		
Teaching	0.967	1	0.907	0.951	productive
Non-teaching	2.370	0.428	0.966	1.124	Non-productive
Mean	1.668	0.714	0.936	1.037	-
P value	0.381	0.001	0.695	0.446	-

Discussion

We measured total hospital productivity using malemquist index. Malemquist index is a useful

technique to assess hospital productivity (20).The results showed that the productivity of hospitals over the years 2007-2010 has increased and had an ascending trend. However, the average of total

productivity was 1.024, which shows 2.4% reduction; and changes in technological performance had the highest impact on decrease in value of total productivity. Different values for total factors productivity have been reported in different researches in Iran and other countries.

A study in Iran showed that just fewer than 60% of all hospitals at were technically efficient and therefore they were non-product because efficiency of units has direct association with productivity trend (2). Chang et al. (8) in a similar study reported increase in the productivity of 31 regional hospitals in Taiwan. The average of productivity changes in the Taiwan's hospitals was (0.874) was lower than average of productivity changes in our study.

One way to increase technical efficiency is decrease of length of stay and increase of hospital size. Masayuki (21) showed that the larger hospitals have the higher productivity. As doubling hospital size lead to increase of productivity more than 10%. Of course, length of stay effects should be controlled simultaneously. It should be noted Productivity change is affected scale efficiency changes, technological performance and managerial performance (13, 15). Najafi et al. (22) reported that the average productivity of the hospitals has declined by 3.3% in Ardebil and the technological efficiency changes had the most negative effects on total productivity. Evaluation of the causes of these effects can be helpful in improvement of the total productivity. The lack of technological innovation in hospitals led to a decrease in TFP change. Technological improvements play an important role in increasing the productivity of larger hospitals (23).

Findings of our study showed that despite improvement in productivity trend of hospitals, the average of productivity of hospitals not improved; this result can be used as a warning in order to make better use of existing resources. Some hospitals (A, B, C, G, H and I) used resources the more appropriate which can be considered as a model for other hospitals (D, E, F, I, J, K and L). In hospitals that the main cause of low productivity is changes in technology efficiency, it seems that lack of enough familiarity of managers with

the advanced hospital technologies, lack of equipment and inappropriate use of technology in diagnosis, care and treatment, are the main causes (22). Limitations of current study were first, databases are not well developed in hospitals. Second, medical record system is manual and third, DEA software has technical limitations.

Conclusions

In the F and K hospitals the main cause of the low productivity is changes in technical efficiency therefore mangers must use inputs (doctors, nurses and beds) efficiently and increase the outputs. In hospitals E that the main cause of low productivity is negative changes of scale efficiency therefore managers must improve the scale efficiency. Finally, according to results of this study, decrease of technological efficiency had the highest negative impact on average of total productivity of hospitals. Therefore, hospital Managers and policy makers can use economic of scale methods including: optimizing size of hospitals, increase of production volume and decrease of the length of stay (by means of discharge process optimizing) for productivity improvement of hospitals.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgments

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